Dynamic impact of Diamond Light Source foot bridge

H. Huang and J. Kay

Diamond Light Source Proceedings / Volume 1 / Issue MEDSI-6 / October 2011 / e30
DOI: 10.1017/S2044820110000547, Published online: 01 November 2010

Diamond Light Source Proceedings, Vol 1, e30, page 1 of 4
MEDSI-6 2010

doi:10.1017/S2044820110000547

Poster paper

Dynamic impact of Diamond Light Source foot bridge

H. HUANG[1] † AND J. KAY[2]

[1]Principal Engineering Analyst, Diamond Light Source Ltd.

[2]Head of Engineering Group, Diamond Light Source Ltd.

(Received 11 June 2010; revised 29 September 2010; accepted 01 October 2010)

The main foot bridge provides access to linac, booster and storage ring facilities in the synchrotron of Diamond Light Source. The impact of the passage of pedestrian traffic and equipment across the bridge structure was noticeable to the site of beamlines below. One of them, I20, is the most sensitive beamline to such impact. The bridge obviously oscillated with even light traffic, and it was also assumed that this would couple to the storage ring structure where the bridge is mounted. The optics for beamline I20, for stability, stands directly on the slab within the I20 experimental area; this was however subject to excessive vibration transmitted by foot traffic from the overhead footbridge producing a vibration on the experimental floor of 86 nm whereas elsewhere in the experimental hall experiences only about 20 nm, demonstrating a four times increase in vibration caused by the pedestrian bridge. Vibration measurements on the ground underneath the bridge and finite element analyses clearly show that frequencies of 2 and 5 Hz were caused by the bridge and traffic on it. Several remedies were proposed. However, dampers will only damp out vibrations of around 5–6 Hz but not to damp out 2 Hz, which is caused directly by human foot steps. After investigation of cost and effectiveness and several vibration tests conducted, a compromise with extra propping at the mid-span of the bridge was eventually selected. Such reinforcement has been now implemented. The 5 Hz frequency has been successfully removed and a amplitude of 2 Hz also considerably reduced.

1. Vibration measurements of the foot bridge

A sequence of vibration tests was conducted in Diamond Light Source experimental hall (Huang and Kay 2006). The aim of these tests was to find the frequencies and amplitudes of vibrations on the main access bridge of the diamond synchrotron. The impact of the passage of pedestrian traffic and equipment across the bridge structure on the beamline below (I20) is significant for optimum operation of the instrument. Several sensors measuring the vertical and horizontal displacements were placed in different locations along the bridge and on the floor directly under the bridge adjacent to the I20 optics hutch in order to study the

† Email address for correspondence: hou-cheng.huang@diamond.ac.uk

frequencies and amplitudes of the impact from traffic on the bridge. As an excitation, a group of people was asked to walk on the bridge continuously during tests. All sensors were placed in the same place during all tests for comparison purposes.

2. Stability requirement for Beamline I20

High stability of the beam is required for the Beamline I20 which is directly under the foot bridge (figure 1). The versatile spectroscopy beamline I20 will become operational soon in the year 2010. The beamline aims to cover three very distinctive modes of operation: (i) X-ray absorption spectroscopy (XAS) on challenging samples, (ii) energy dispersive EXAFS (EDE), and (iii) X-ray emission spectroscopy. I20 is equipped with two wigglers in the same straight section, one for the scanning branch and the other for the dispersive branch. The scanning branch will offer monochromatic X-rays with high flux and high spectral purity in energy resolution and harmonic content for transmission and fluorescence measurements. The dispersive branch will be optimized for *in-situ* time-resolved X-ray spectroscopy studies. I20 will support a wide range of applications, especially in biology, environmental science, chemistry and materials science. To guarantee the stability as quiet as reasonably achievable for such sensitive beamline, the vibration from the foot bridge has to be resolved by removing some lower frequencies or reducing their amplitudes.

3. Finite element modal analysis

A modal analysis was also performed to determine the natural frequencies and mode shapes of the bridge. The natural frequencies and mode shapes are important parameters in the design of the bridge damping. The first of two modes has been calculated and reasonably compared with the tests. Mode shape pictures as shown in figure 2 were informative in understanding how the bridge vibrated,

FIGURE 1. Main foot bridge.

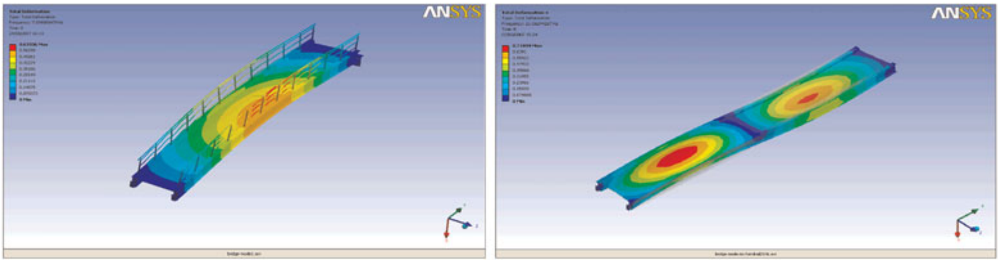

FIGURE 2. First and second modal shapes by finite element analysis.

FIGURE 3. Bridge with props.

although did not represent actual displacements. Such frequencies and shapes represented the dynamic behaviour of the bridge without any loads. However, if there are structural loads present in the environment, then the frequencies and magnitudes of bridge vibration will be slightly different. In fact, the first natural frequency is 7 Hz, while in the vibration test 5 Hz was measured and also there was 2 Hz frequency caused by traffic loads on the bridge.

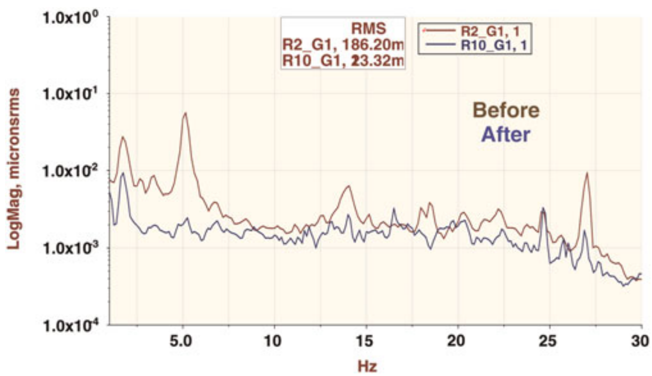

FIGURE 4. RMS spectrum.

It is clear from the mode shapes that if props were employed to support the bridge at its mid-span, the first mode would be removed. To confirm this, a prediction test was conducted with two temporary supports to shift the first natural frequency higher in the spectrum. The results were encouraging. The 5 Hz frequency disappeared and the amplitude of 2 Hz was also significantly reduced.

4. Implementation with propping

By the end of 2009, permanent props for the bridge were installed as shown in figure 3. Vibration measurement was conducted and compared with previous data. The locations of such measurement included the floor inside the optics hutch right under the bridge to establish whether or not bridge propping has improved the vibration response measured at the optics location in beamline I20. In figure 4, the light curve represents vertical RMS spectrum before propping and the dark curve represents vertical RMS spectrum after propping. An apparent improvement of the bridge vibration under traffic loads is achieved.

REFERENCE

Huang, H. & Kay, J. 2006 Vibration measurement at diamond and the storage ring response. *10th Biennial European Particle Accelerator Conference*, EPAC'06 CD-ROM, Edinburgh, UK, pp. 26–30.